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Practical Decision Making – From the Legacy of Herbert Simon to Decision Support Systems

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Abstract

Herbert Simon is one of the key researchers whose work has been drawn upon constantly by IS researchers. In this paper, we examine his legacy and illustrate his impact on the research carried out in the decision making area. Although he did not directly work on the concept of Decision Support System, much of his research can be regarded as theoretical foundation for DSS. We examine his contribution to the evolution of ideas in the DSS area and discuss the significance of his legacy for DSS.

Keywords

Herbert Simon, Decision Support Systems, Bounded Rationality, Legacy

1. INTRODUCTION

Since the late 40's, Herbert Simon has been unequivocally associated with management and decision. None of his contemporaries have had such a far-reaching impact on management, especially when his further work with James March is considered and Mintzberg himself, who considerably advanced our ideas on management practice, noted that he always considered Simon to be the most influential and important contemporary author in terms of organizational theory (1990, p. 94). Jared Cohon, president of Carnegie Mellon University, where Simon was a fixture for 52 years said "few if any scientists and scholars around the world have had as great an influence as had Simon across so many fields, economics, computer science, psychology and artificial intelligence amongst them" and David Klar, a professor in the university was moved to say "it should be named Carnegie Mellon Simon university" (Spice, 2001).

This legacy leads us to review Herbert Simon's contribution to the decision making and decision support areas and to show how the science and practice of management and decision making changed under his influence. We also consider to what extent his work, notably his pioneering research into the decision-making process within economic organizations (for which he received the Nobel Prize in 1978), contributed to the establishment of DSS as a field of research. This paper first considers the new ideas brought by Simon in management theory and then looks at his contribution to our understanding of managerial decision making and DSSs. It concludes by raising some questions for DSS designers.

2. THE MANAGER AS A DECISION MAKER

In his biography, Simon (1991, p. 64 and *seq*.) explains how he entered the city government in the town of Milwaukee and how he worked with Clarence Ridley from 1936 on the evaluation of community activities. From the observations gathered during his years at Milwaukee and from his teaching and lecturing at the University of Chicago, Simon realized intuitively that he might set up the basis of a science of management, a science that should ideally be as falsifiable as the other sciences, though Simon did recognize that he was only at the very beginning of this ambitious project (ABo, p. xi)[1].

[1] The references to the book "Administrative Behavior" are denoted ABo (o=old) for the elements of the 1947 edition and ABn (n=new) for those elements taken from the comments added to the 1997 edition. In all cases the page number refers to this latter edition. The book "Administrative Behavior"is largely based on the PhD thesis that Simon wrote between 1939 and 1942, while at Berkeley (Simon, 1991, p.85).

Simon saw himself as one of the pioneers of the second generation of scientific management, after Fayol, Taylor and others. It was above all Taylor who attracted his attention. Taylor (1911) published "The Principles of Scientific Management", a book dealing mainly with the improvement and effectiveness of production processes and the role of human labor in the elementary operations in production (ABn, p. ix ; O[2], p. 32-34). It was doubtless no coincidence that Simon's book on the introduction of computer science into management was entitled "the New Science of Management Decision". In the preface to the 1977 edition, Simon actually wrote (p. x) "The computer and the new decision-making techniques associated with it are bringing changes to white-collar, executive and professional work as momentous as those that the introduction of machinery has brought to manual jobs".

Simon's basic idea, as expressed in "Administrative Behavior", is that the correct angle from which to approach a study of organization management is that of the *decision and the action* that follow (ABo, p.1). Thus, the manager must primarily be viewed as a decision maker (Simon, 1977, p. 39). This is well characterized in the book with March (On, p.3) : "The central unifying construct of the present book is not hierarchy but decision making, and the flow of information within organizations that instructs, informs, and supports decision making processes". This became the unifying thread in Simon's future work on decision making and Simon described himself (Simon, 1991, p. xvii) as somebody "who has devoted his scientific career to understanding human choice". Thus, Simon's ambitious program was to understand organizations and their management as an aggregate of human choices; not like in economics theory based on the abstracted behavior of *homo œconomicus*, but based on the real behavior of people.

Pre Simon, the field of decision belonged to economics rather than management and the dominant model was that of maximizing a utility function under constraints, ideas that came from von Neumann's game theory and the theory of markets and supply-demand equilibrium, as illustrated in the work of Pareto, Edgeworth, Walras and, more recently (at the time) von Neumann. But as Simon observed (ABn, p. 20), markets tell us nothing about organizations and firms, and in particular, economic theory tells us nothing about the technology underlying production, nor of the motivations that inspire the decisions of managers and employees or the process that leads to "optimal decision". The theory is not concerned with how those involved acquire the necessary information, how they perform their calculations, or more importantly still whether they are capable of correctly evaluating the consequences of the decisions, according to the events, as postulated by the maximization of utility (ABn, p. 20).

Simon's second breakthrough after he introduced decision as a subject for investigation and as the unifying thread in the analysis of organizations was his conviction that the structure of organizations plays a key role: "In the study of organizations, the employee must be the focus of attention, for the success of the structure will be judged by his performance within it". (ABo, p. 2). Thus, Simon deliberately set himself within the framework of 'social psychology' (ABo, p. 2).

This sociology of analysis and field investigation, as sketched out in the work of Simon, was brilliantly developed in the work of March and, in France, by Crozier (1963). The latter was without doubt the first to introduce Simon to French researchers, in the preface to the French edition of the book of March and Simon (1974)[3] and, in his article on Simon in the newspaper "*Le Monde*" on the occasion of the Nobel Prize for economics in 1978, Crozier referred to Simon as "the father of the sciences of decision"[4].

A key consequence of Simon's observations and ideas is that decisions and the actions that follow them cannot easily be distinguished. Thus, Decision support systems should primarily be geared as models for action, but action in an organization is a cascade at intertwined sub-actions and consequently DSS design must accommodate human reasoning at a variety of levels, from the strategic level to the lowest level of granularity of action decided by managers. However, we believe that this has not been applied in the practice of DSS development, and that DSSs have focused on high level decision making (strategic decision) but using low levels of representation (data, equation, etc) because (1) the notion of representation level has not been sufficiently studied and (2) high level decisions are more appealing than small decisions (Humphreys and Berkeley, 1985; Pomerol and Adam, 2003b).

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[2] References to the book by March and Simon "Organizations" are denoted O and On for the preface to the second edition. In all cases the page number refers to the later edition of 1993.

[3] Dunod, Paris

[4] "Yet with time it has appeared more and more clearly that Herbert Simon is the father of the modern sciences of decision, that his complex but always very practical ideas have constituted one of those rare revolutions in contemporary social science and that the scope of his influence is being felt more and more deeply not only in the thinking but also in the practice of action" (Crozier, Colloque de la Grande Motte, 1984, in Demailly and Le Moigne (1986, p. 673)).

3. DECISION PROCESS

To deal scientifically with decision, Simon began by distinguishing between facts and values (ABo, ch. 3) or what is and what ought to be. This aspect of Simon's work has been criticized because it does not clearly formalize the role of future events. Facts are what can be verified or falsified, whereas values are the objectives of the decision maker and, beyond this, his actual wishes. It follows that we can only evaluate a decision if we know the objectives of the decision maker (ABo, p.56 and *seq*.) This notion, reminiscent of the idea of aspiration level introduced by Dembo (see Lewin *et al*., 1944), was adopted by Simon and became an important feature of his "heuristic" search. Many interactive methods in decision making rely on the notion of local adjustments according to the level of satisfaction reached at every given step. This is a basic tenet of "bounded rationality" (see Selten, 2002). Thus, to evaluate the quality of a decision, researchers must know the utility of the decision maker, and understand what he or she expects in terms of the probabilities of future events (this aspect was not specifically studied by Simon).

2.1 Towards a model of the decision making process

Simon observed that the problems that trigger decisions are not factual data but constructs. In his own words: "problems do not come to the administrators carefully wrapped in bundles with the value elements and the factual elements neatly sorted". Secondly, he observed that decision "is a matter of compromise", i.e. all decision makers have several more or less contradictory objectives in mind. Thus, Simon was the first to stress the multicriterion aspect of decision.

Based on these observations, Simon (ABo, p. 77) laid the foundations for his seminal model of decision making. He broke down decision making as follows:

1. identify all the possible alternatives;
2. determine all the possible consequences of these alternatives;
3. evaluate all the possible consequences.

In contrast with the simplistic view of Dewey[5], Simon is clearly interested in the mechanics of the decision making process, in that he considers how a decision maker evaluates all the consequences and compares them with each other. This is a central problem in any decision process in that evaluating consequences requires that managers have a complete knowledge of all future events and their probabilities.

Drawing from his work on psychology, Simon also discussed the role of 3 key factors of cognitive load in decision making: attention, information and stress. Given the limited cognitive capacity of humans, attention is a limited and even rare resource which plays an important part in decision making. This theme is central in Simon's work with March (" … the ways in which attention is allocated are critical to understanding decision" (On, p. 4)). Cognitive limitations play a substantial role in the concept of bounded rationality in that, as Simon stressed, they preclude the exhaustive study of all of alternatives and their consequences. This led Simon to present his famous four phases (Simon, 1977):

- intelligence
- design
- choice
- review.

The role of information and attention is particularly fundamental in the first two phases of decision making because managers can only choose between alternatives that they know about and that they are able to document. As Simon pointed out: information acts as a constraint on decision. This role of information is often a source of weakness in DSSs, because many designers emphasise the models they build into their systems rather than the significance of the information fed into them.

Simon was aware of the interdependence between the phases and he provided examples of feedback from one stage into another. He also indicated that each stage can be considered recursively as a decision in itself (Simon, 1977, p. 43). Thus, his model enabled him to eliminate the common problem faced by decision making researchers thus far, namely the artificial reduction of decisions to the moment of choice (see also Langley *et al.*, 1995). He said: "All the images falsify decision by focusing on the final moment" (Simon, 1977,

[5] 1) What is the problem ?; 2) What are the alternatives ?; 3) Which alternative is the best ? (quoted in Simon, 1977, p. 43).

p. 40). This new idea was to bring the study of decision making out of the mythology of management stories and link it firmly to the field of Information Systems.

2.2 Programmable and non-Programmable Decisions

As Simon's thoughts gradually turned toward the computer, he introduced another oft-quoted aspect of decision: the distinction between programmed decision and non-programmed decision (Simon, 1977). He stated: "Decisions are programmed to the extent that they are repetitive and routine, to the extent that a definite procedure has been worked out for handling them so that they don't have to be treated from scratch each time they occur" (Simon, 1977, p. 46). Decisions on the other hand are non-programmed "to the extent that they are novel, unstructured and unusually consequential" (Simon, 1977, p. 46). The fundamental unity of Simon's thinking is evident here, for organizations, like computers, are systems designed for "complex information processing" (Simon, 1977, p. 15). The processing of information for decision is the key to the whole of Simon's work. Programmed decisions obey computer programs or other programs that are computerizable, while non-programmed decisions come under the heading of "problem solving" (Simon, 1977, p. 64-65). Thus, programmed decisions can be modeled in DSSs whereas problems that cannot be modeled are outside the realm of DSS. From these ideas stems the classical belief that semi-programmed decision are the real target of DSSs and that DSSs must be interactive so the decision maker can complement the part of the model that is not "structurable".

The issue of determining whether a decision lends itself to programming is at the core of the concept of organizational learning, which then became widely investigated, in particular by March. The issue of recognizing 'decision patterns' also emerged and led to 'case-based reasoning', which became a recurrent research theme in artificial intelligence (Pomerol, 2001).

4. FROM SUBSTANTIVE RATIONALITY TO BOUNDED RATIONALITY

Initially, Simon adopted the generally accepted definition of rationality as the matching of means to ends. This has been found to raise more problems than it solves as an individual can draw any conclusions from a false premise and that any decision relying on an erroneous diagnosis may be found to be rational in some sense. Simon (1983, p. 9-10) was aware of these problems and he stressed that a process can be rational though the facts initially considered (the diagnosis in Pomerol, 1997) are false.

There has been considerable evolution in Simon's ideas between the first edition of his book and his most recent comments (ABn, p. 163) in which he considerably qualified the relation between objectives and decisions by showing how the objectives and the constraints are interchangeable in the role they play in defining problems. This issue can be illustrated with a simple question: is the use of fewer raw materials in production an objective or a means – or a constraint in supply procurement? Simon also emphasized that among the constraints, some can become objectives at a given time in the management process, and return to being constraints at other times, depending on the focus of the decision maker on one aspect or another. In an organization, an intermediate objective often becomes a means. For example, if a firm's objective is to maximize profit, then the objective 'increasing sales by 20%' may be represented as either a means or an objective. From this stems the idea of organizational chains of means and objectives (ABo, p. 83), which further complicates the evaluation of decisions. In his comments, Simon emphasizes (ABn, p. 161-162) that the multi-layered aspect of most decision rules out optimization as a practical model for decision making. In DSSs, the designer is frequently faced with this question: the constraints are a part of the model whereas the objectives depend on the decision maker and his or her evaluation. The designer will therefore have to choose between two options in dealing with each decision rule. This is an aspect of bounded rationality that Simon first referred to as *"procedural rationality"* (Simon, 1976).

Later, Simon was led to focus on the limitations that apply to human cognition and to formulate a number of assumptions which became the foundations of what, in 1955[6], he termed "*bounded rationality"*. These can be summarized as follows:

- it is impossible to assign probabilities to all events or even simply to enumerate all possible events and their combinations;
- decision makers' preferences are not rational in the sense of maximization of a utility function. They are in fact multicriterion and also changeable, meaning that it is impossible to spell out an overall utility function for a given choice;

[6] A behavioral model of rational choice, *Quaterly Journal of Economics 69*, 99-118, reprinted in *Model of Thoughts* (Simon, 1979, Chap 1.1).

- decisions spread out over time and, in organizations, form a chain in which, over time, sub-decisions are not mutually independent, but can be taken at different times and levels using non-identical criteria; furthermore, we cannot separate preferences, actions and objectives. As Simon (1983) stated: "the fact that sub-decisions are taken locally using partial criteria obviously – and, I would add, mathematically – counters any global optimization" (p. 18);
- available information is fundamental and very strongly affects decisions; this is particularly evident when considering the (small) number of alternatives an individual is capable of contemplating. Attention plays a considerable role in delimiting problems and affects the subsequent decisions in that *attention is a rare resource*.

Simon concluded from these assumptions that managers must content themselves with sub-optimal or *'satisficing'* decisions. In practice, given these limitations, the decision process stops when decision makers reach a solution that satisfies them within what appears to them to be the most probable hypothesis. This notion of *'satisficing'* tends to become more and more preponderant in Simon's work after 1960 as evidenced in Simon (1983) for instance. The limited rationality of 1955 gradually gives way to 'bounded rationality' (Simon, 1972) and is increasingly represented in an algorithmic form already present in 1955 as the *'satisficing rule'*. This algorithmic aspect highlights the sequential aspect and *heuristic search* nature of decision processes. This development went hand in hand with Simon's growing interest in artificial intelligence. The algorithmic aspect of the bounded rationality can be summarised as the use of fast and frugal rules for 1) the heuristic search; 2) stopping the search and 3) the choice (Gigerenzer, 2002).

As Simon's thinking developed, cognitive limits, with the brain as a symbol processing system, became increasingly important elements in bounded rationality. "In its simplest form, the theory of bounded rationality is a theory of "how to live" in an infinite world, while disposing of very limited computational means (Simon, 1984, p. 595). Simon concluded that: "So long as human attention is a rarer resource than information, we have to re-think our organizations in terms of attention management" (Simon, 1984, p. 590).

The notion of bounded rationality has had immense repercussions over the last 50 years as the first attempt at setting up a scientific framework within which the real decisions of real decision makers in real organizations could be studied against real efficiency criteria. In addition, this framework took into account the cognitive, informational and reasoning limitations of individuals and we contend that bounded rationality is a description and a representation of the way in which decisions are made in organizations. Subsequently, Simon frequently opposed procedural rationality – the rationality that takes into account the limitations of the decision maker in terms of information, cognitive capacity and attention[7] – to substantive rationality, which is not limited to satisficing, but rather aims at fully optimized solutions.

5. DECISIONS AND ORGANIZATIONS

Bounded rationality focuses on the individual's decision making within an organization, but in fact Simon was mainly interested in organizational decision making and the duality stemming from the fact that, while it is individuals who make decisions, it is meaningful for researchers to view organizations as having a life of their own. This duality led March and Simon (ABn, p. 229) to investigate a number of key issues, including:

- the relationship between individual preferences and the objectives of the organization;
- the role and limits of authority and the hierarchy;
- channels of communication;
- departmentalization and decentralization in organizations;
- why people get involved with and remain in organizations (ABo, p. 157). This is central in the book by March and Simon and leads to the notion of organizational equilibrium present in nearly all Simon's books;
- the role of individual psychology in constructing the company culture;
- how the above factors impact on decision making.

Several aspects of Simon's vision are innovative. Firstly, authority and power are given their first serious definition since Dahl and Crozier's work (Jameux, 1984). Authority is defined as: the ability to make decisions

[7] "The idea of limited, consequential rationality found in the book has become more or less standard in modern theories of decision-making, at least outside the core of orthodox neoclassical economic theory" (On, p. 9)

that engage the actions of people other than the decision maker (ABo, p. 179) and the power to arbitrate between viewpoints when there is no consensus. This led Simon to investigate the extent to which a decision made by top managers in the absence of a consensus is acceptable to subordinates and how this affects the execution of such a decision. Simon called this *'the area of acceptance'*.

Simon's approach was to investigate the interaction between the organization and its structures on the one hand, and the behavior of the individual decision maker on the other hand. The idea was that the institutional setting should enable the individual decision maker to take the right decisions for the organization. Thus for Simon, the organization provides a setting which, by various means (definition of objectives and criteria among others) affects the decision making of its members (Simon, 1977, p. 51). Such ideas have since led to the notion of *decentralization through objectives* and, in a wider sense, of *corporate culture*. In connection with power, mention should be made of the interesting notion of 'uncertainty absorption' (O, p. 187) which Simon defined as reasoning from previously processed facts or intermediate conclusions rather than from the facts themselves. This is a fundamental notion in the study of bureaucracies where decision makers have little contact with the real world and make little attempt to collect fresh evidence from the field.

Secondly, Simon put forward the idea of the organization as a 'role system' (ABn, p. 230) - the role of the organization and that of its people; and how each individual adopts their socially inherited role. Simon attempted to understand how, through role playing, the institution channels individual behavior. The role of groups and group-individual relationships are widely investigated in the book "Organizations", perhaps under the influence of March. Subsequently, this theme of social pressure on the individual was to develop in the themes of alienation and manipulation. However, unlike March, Simon always remained more of a psychologist than a sociologist in his work on organizations. It was left to Cyert and March to bring the fundamental contributions that inspired future generations to consider such problems as the avoidance of conflicts, 'the control' of avoidance of uncertainty, organizational learning and problem-driven decision (see *e.g*. Crozier and Friedberg, 1977).

Simon borrowed from Freud the notion of *identification*, which he considered from two points of view: the identification of the individual with his personal role and his identification with the organization (the issues of loyalty). For Simon, the processes of identification involves the personal share that the individual has in the success of the organization, an acceptance of the philosophy of private enterprise and the value of success, and finally, a key idea that managers' decision making should be reduced to what is right for the organization (ABo, p. 295). Simon's experiments (ABn, p. 296 *et seq*.) showed that on the whole, accountants formulate any organizational problem in accountancy terms, sales representatives in terms of sales, etc. This problem of the selective perception and interpretation of stimuli according to existing schemes is also found in pattern recognition and in the science of the artificial (Simon, 1981), but it is also important in economics, in psychology and in sociology.

Throughout his work, Simon accurately anticipated, even before the World Wide Web became what it is now, the stream of information of all kinds which organizations are facing. For organizations the most critical task is not to search for or to generate still more information but to filter it so that it does not exceed their processing capacities (Simon, 1977, p. 108). For managers, a similar problem arises, and hence the importance of intelligent 'interactive decision support system' filters. Even today, this serves as a justification for the field of DSS as a key area of scientific research.Citations should be in Harvard style. This involves references to White (1979) or to a publication (White 1979). Multiple authors (three or more) are referred to as Black et al. (1982). Multiple publications by the same author within the same year are differentiated as Grey (1983a, 1983b). Where the author is unknown, or is an organisation, an appropriate surname or organisation name or acronym is used. e.g. (IFIP 2002).

6. DISCUSSION

6.1 Management and decision making

Simon's views about post-industrial society, the utmost importance of information and the role of the manager as a decision maker have been largely confirmed and are still central in DSS research and practice (Power, 2003). Furthermore, the need for more research on the links between action and decision called for by Simon still applies today. In particular, the issue of whether action is the last step of decision and should be included in the process is still unresolved. This may mean that DSSs should not be only deliberative but also decisive. It is our experience that most of the time they are not and that decision makers remain absolutely necessary because action (in a social framework) is also intention and commitment. Even March who is more sensitive to social aspects than Simon does not develop these ideas much. For DSS design, this means that current systems are not sufficiently tailored for supporting action.

6.2 Decision process

Today, there is wide agreement that the decision process cannot be reduced to choice (Langley *et al.*, 1995), and the role of information and the building of possible alternatives are widely regarded as critical. Lewis (1991) noted that nearly 75 % of authors of information system manuals adopt Simon's decision phases as a unifying thread. It is also broadly believed that managerial decision processes depend on information and the organization as well as on the individual decision maker (eg: Berkeley *et al.*, 1998). DSS designers must endeavour to grasp the implications of these ideas because for a long time decision support unduly focused on the moment of choice. It is relatively recent that some DSSs and EISs address the information gathering phase by aiding the decision maker in data miming and extracting information from databases and data warehouses, by proposing better interface designs to help managers searching. Thus, in Power's (2003) typology, at least three on five types of DSSs focus on information and data: Data-Driven DSS, Knowledge-Driven DSS and Document-Driven DSS. In addition, reviewing decision and learning from them have not truly been considered by DSS designers and are to be found in the realm of artificial intelligence. Only experimental case-based DSSs attempt to improve their decision process through use.

The notions of heuristics search and "satisficing" decision have been widely adopted by DSS researchers. Interactive searches, reference point methods, local searches, etc, generally invoke Simon as a source of inspiration. Interactive DSSs, for instance, generally perform a heuristic search directed by the decision maker who progressively elicits his preferences, and stop at the first "*satisficing*" decision they find (Pomerol and Adam, 2003a).

On the other hand, DSS design still faces an uphill struggle in relation to the design of possible alternatives in decision making as most DSSs treat alternatives as given and unchangeable. This is a difficult topic, mainly because alternative building follows a top-down process along the representation levels: starting for very general ideas, progressively refined towards lower level representations and towards action (Humphreys and Berkeley, 1985; Lévine and Pomerol, 1995; Pomerol and Adam, 2003b).

A final issue deserves consideration in assessing Simon's contribution to the DSS field: whether the very famous distinction between programmed and non-programmed decision has proven useful. We think that it could be advantageously replaced by a more easily operationalisable differentiation between automatic and interactive DSSs. It may not be very significant to say whether a DSS addresses non programmed decisions, whereas it is clearly observable that in some cases the designer is unable to produce a complete model - especially for choice (Pomerol and Adam, 2003a) - and that the human decision maker consequently remains a key element in the process.

6.3 Bounded rationality

In section 3, we reviewed the key aspects of bounded rationality. There is some agreement that the behavior of human decision makers has been well captured by Simon. However, divergences occur about the applicability of this model (eg: Rubinstein, 1998). Bounded rationality is a fuzzy concept and as such it is not clear exactly how it should be used, given its highly subjective nature: how can an alternative be adjudged to be satisfactory by somebody other than the decision maker? The rational procedure of searching for a good alternative (heuristic search) is without doubt the most practically applicable part of the concept. Bounded rationality tells us that collective utility functions and many so-called optimizations are no more than hot air: we often hear top managers, politicians and technocrats claiming that they have *made the best possible decision for the common good*, a rather ambitious claim which assumes a God-like knowledge of a hypothetical collective utility function and – above all – of future events.

Simon undoubtedly thought that maximization is nonsensical, due to:

- lack of knowledge of probabilities
- multilevel, multi-stage, multi-criteria decision process
- the fact that the preferences are not exogenous to a decision
- attention is a scarce resource

Then, it is perhaps surprising that Simon rarely refers to risk and its evaluation. Numerous experiments and much research on how people choose in risky and uncertain situations were by other researchers – eg Tversky and his students and followers, who developed most of our knowledge on decisional bias (cf. overviews in Kahneman *et al.*, 1982; von Winterfeld and Edwards, 1986; Bell *et al.*, 1988; Piattelli-Palmarini, 1995; and Kahneman and Tversky, 2000).

On the one hand, although researchers have considered the influence of individual traits in decision making, very few DSS studies refer to decision bias and are focused on specific aids to overcome them. In particular, although it is clear that human processing of risk (*e.g.* probabilities) is very poor, very few attempts have been made to tackle the problem. In addition, DSSs are still individual and even if groupware decision has been intensively studied over the last fifteen years, we still do not see DSSs as social devices and almost no research exist on the impact of decisions and on the structure and behavior of organizations.

The second main field opened up by bounded rationality is multicriterion decision making and, more generally, the extension of operational research ('optimizing in essence') towards artificial intelligence (Simon, 1987). The use of heuristics and the so-called local methods in O.R. owe much to the impetus given by Simon and his students. A multiplicity of criteria and the resulting non-optimization are among the features of bounded rationality that contributed to the rapid development of multicriterion decision. The multicriterion aspect has always been present in bounded rationality, with 'partial ordering of payoffs' as a consequence (Simon, 1955). This multi-dimensional character is the result either of having a large number of incommensurable objectives (Simon, 1967), or of the fact that several individuals are involved in a group decision. This led Simon to conclude that the quest for a global optimum did not make sense. On this point Simon has had much following and multicriteria DSSs are now commonplace.

The two remaining aspects of bounded rationality that led to further research are the question of the endogeny of the preference and the problem of limited attention. In DSS research and practice, the former has been solved by letting the decision maker express his preference using interactive features of the system, while the latter has been addressed by developing simple easy to handle systems rather than involved systems. This is illustrated by the shift from DSSs with relatively sophisticated models to EIS, with few modelization and very effective displays.

6.4 Decisions and organization

Beyond bounded rationality, the impact of the work of Simon and March on sociology has been crucial. By rehabilitating the sociology of organizations and considering the interaction between the behavior of the individual and the structure of organizations and decision processes, they also totally renewed business economics, showing that a scientific approach was possible with proper experiments and measurements. The most inspired part of the work of Simon is probably his reflection on how we account for the behavior of the individual within the collective behavior of the firm.

Simon, especially in collaboration with March, paved the way towards the notion of organizational learning and all subsequent investigations in this area. Some ideas that arose from their work include the notion that the structuring of decisions leads to the creation of routinised processes and the issue of how organizations create their procedures and maintain them. *What is the knowledge of an organization* and *how is it acquired and maintained*, remain critical research questions that still fuels much debate and questioning (cf. Zacklad and Grundstein, 2001 for recent references).

Organizational learning and knowledge management have received a large attention in decision making research (as illustrated by the themes of previous IFIP 3.3 conferences). Information Systems such as data warehouses now frequently underlie DSS building. Learning, however, is not reduced to knowledge accumulation, but also encompasses rules, procedures and routines generation. This last aspect is not well studied and although some rule extraction methods have been proposed (statistically based or using more qualitative methods in artificial intelligence), it is still not well spread in the DSS field.

Lastly, Simon's contribution must be examined in light of his work with Cyert and March and their book "A Behavioral Theory of the Firm" (1963). As the title suggests, this is about re-introducing human behavior into theories of the firm. This work led to the concept of transaction cost (reflecting the fact that information and time have a price) which earned Coase the Nobel Prize (Coase, 1988), agency theory and new ideas on the concept of firm illustrated by the work of Williamson on contractual and transactional analysis in firms. Williamson analyzed the behavior of agents as decision makers with bounded rationality. This led him to discuss the firm as opposed to the market in terms of adaptation to changes in the environment and speed of reaching a decision[8] (Williamson, 1991).

8. CONCLUDING COMMENTS

Thus, Simon's legacy is considerable. In the four fields mentioned above, Simon was a forerunner whose work is still central today. His ability to collaborate with others and his gift for communication, borne out by the

[8] A good review of these theories can be found in Coriat et Weinstein (1995).

large number of co-authored papers - over 80 in all (Simon, 1991, p.387) – made him a great source of inspiration for many and ensure his place in posterity. It is worth to note that despite the uncertain aspects of the fields of management and decision (particularly as they were in the 40s and 50s), Simon always managed to stick to facts and, in his own words, to accept nothing that cannot be upheld by the facts. Though a champion of bounded rationality, Simon was a rationalist himself. As March puts it (quoted in Weil, 2000, p. 35): "Herbert Simon is an unrepentant knight of the enlightenment. Not Freud, but Descartes [....] He studies the limitations of reason in the name of reason". Bounded rationality is not the absence of rationality, but rather the question of what one can do that is rational without full knowledge of the facts. This is why Simon is often described as 'an enlightened man'. Certainly an enlightened man, but also a true scientist.

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